APPENDIX 10

RHIC Collider Tunnel

Life Safety Analysis

Brookhaven National Laboratory

Prepared by: J. Levesque

Date: 7/15/92

BROOKHAVEN NATIONAL LABORATORY
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Office of the Director

August 12,1992

Frank Crescenzo
Deputy Area Manager
U. S. Department of Energy
Brookhaven Area Office
Upton, New York 11973

Re: Change in RHIC Collider Tunnel Fire Protection

Dear Mr. Crescenzo:

Attached is a technical basis document that justifies a change in approach for the RHIC Collider Tunnel sprinkler protection. A commitment for sprinkler protection for the Collider Tunnel was made in the June 1991 Relativistic Heavy Ion Collider (RHIC) Preliminary Safety Analysis Report (PSAR), page 46. Sprinkler Protection throughout all areas is no longer required for the conditions that will now exist in the Collider Tunnel. We are providing this to you for your information and comment.

Sincerely yours,

M. S. Davis,
Acting Associate Director

attachment
jl/FP5020.92 (RHIC)
cc: W. R. Casey
J. Durnan w/attach
S. Kane w/attach
S. Musolino w/attach
E. P. Rohrer
F. Thornhill w/attach
J. Deitz
M. Harrison
J. Levesque w/attach
S. Ozaki
M. Schaffer w/attach
J. Yeck (DOE)

Executive Summary

The original designs of the Collider Tunnel for the RHIC project was done for the former ISA and CBA Projects. Under those construction projects, the Collider Tunnel was constructed with the intention of not installing full sprinkler protection. This required a deviation from the 1985 version of the National Fire Protection Association's Life Safety Code, which is DOE mandated.

Under the project before RHIC, the initial approach was to comply with the Life Safety Code in effect at the time of design, as required by DOE. During the progression of the project, the Life Safety Code changed. Formerly, the Collider Tunnel's configuration would require complete sprinkler protection. With the completion of four recommendations, the 1991 Code allows the existing configuration without full sprinkler coverage (local sprinkler protection maybe provided for non-life safety issues).

The cost of sprinkler protection was originally estimated at less than $100K for full coverage. It has since been redefined at a cost in excess of $250k. DOE criteria (ie. life safety, property protection, programmatic protection nor environmental issues) with the Collider Tunnel does not require the sprinklers to be installed. This represents a change from the commitment in the PSAR for RHIC.

Life Safety Code Analysis
Brookhaven National Laboratory
Analysis of RHIC Project Collider Tunnel (1000 Series Buildings)

Date of Analysis: June 15, 1992

Conference with: S. Musolino, Assistant to Project Head for ES&H
F. Thornhill, Enviromental Health & Safety Coordinator

Reference Documents: RHIC Preliminary Safety Analysis Report, June 1991
National Fire Protection Association Code 101, 1991

Scope

This is an analysis of the level of life safety (ie. the ability of the occupants to exit during a fire) and compliance with the Life Safety Code[1]. Compliance with the code is required by DOE Order 5480.7[2].

Summary

The use of the facility, as described under "Occupancy", is a low hazard, infrequently occupied, facility. The facility complies with vast majority of the Life Safety Code requirements. The facility is safe for use. The recommendations provided do not pose an imminent hazards.

Recommendations

1) Replace the existing unrated fire doors for the following areas:
   a) Mid sextant stairway doors are a horizontal exit and require 1-1/2 hour doors
   b) Utility tunnel doors from the support structures to the Collider Tunnels require 1-1/2 hour doors since they are horizontal exits.

2) The detection system within the Collider Tunnel needs to be restored to working order prior to beam line construction by BNL personnel.

3) The magnet enclosure's smoke removal system shall have it's automatic actuation feature connected to the fire alarm system.

4) Provide the emergency generator for back up lighting prior to beam line construction in the Collider Tunnel.

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[1]National Fire Protection Association No. 101, Life Safety Code, 1991 Edition

[2]US Department of Energy Order No. 5480.7, Fire Protection, 11/16/87.

Analysis

The following analysis applies to the RHIC Collider Enclosures. **It excludes the intersecting regions where experimental apparatus and associated support structures are located** (see Attachment 1). Exit paths through these areas are defined and being ensured under separate guidelines for experimental facilities. The actual life safety evaluation for the excluded areas are covered in separate reports. The purpose of this analysis is to document the level of life safety present in the Collider Tunnel.

Building Construction

The Collider Tunnel is a one story, horseshoe shaped tunnel with a total circumference of 12,578 feet (including the intervening Experimental Halls, which are 2,578 linear feet of the circumference). The cross sectional dimensions are 11 foot 1 inches high at the center and 15 foot 4 inches in width at the floor. A sketch is shown in Attachment 2. The tunnel is covered with thirteen to nineteen feet earth for radiation shielding.

The interior finish of the Collider Tunnel is of unfinished galvanized steel with bare concrete on the floor. This has a 0 flame spread rate as per ASTM E-84.

Fire Protection Features

The tunnel is provided with complete fire alarm service. Smoke detectors are spaced every 60 ft. Manual fire alarms boxes are located at exit points and periodically around the enclosure. Fire alarm bells activate upon any alarm signal. Alarm signals and supervisory signals respond back to BNL's Fire/Rescue Group. The fire alarm system meets NFPA 72 for a Style B Type 7 System.

Since the Collider Tunnel has been idle since the CBA Project, the fire alarm systems need to be reactivated prior to beamline construction (Recommendation 2).

Due to potentially difficult access into the areas (ie. long distances with several turns), the tunnel enclosures are provided with a four inch standpipe system. Standpipe outlets are spaced every 100 ft. They are provided with 1-1/2 inch outlets. The system was examined for potential use as a sprinkler main. While the flow capacities were adequate, the costs were exceedingly high (see Attachment 3).

Supplemental to the Life Safety Code requirement, a smoke removal system has been installed. The system provides one air change every six minutes. The flow pattern of the system has fresh air being supplied from the exit points (Exit/Equipment Alcoves, Stair entrances). Exhaust fans are located at mid points between exits. The concept being that a person would always be traveling toward fresh air should a fire or oxygen deficiency occur.

Fire extinguishers are provided every 150 ft. in the Collider Tunnel, in accordance with NFPA 10, for Class A:C light hazard occupancies.

Occupancy

The Collider Tunnel is used to house the RHIC machine, which consists of two, interlaced, concentric rings of superconducting magnets, rf accelerating systems, vacuum piping and pumps. See Attachment 2 for a representative picture of the tunnel's occupancy.

The RHIC machine consists of cryogenic magnets, vacuum lines, cable trays and beam positioning equipment. The primary combustibles are the cables in the cable trays and one or two quarts of pump oil located in the vacuum pumps. Cable tray fires are not fast spreading and do not pose a overwhelming fire risk to the occupants. The majority of RHIC cables will have Limited Oxygen Indexes above 40 (ie. difficult to burn) or have vermiculite bag fire stops located periodically on the cable tray system (see RHIC PSAR, page 45). The magnets are metal, filled with inert liquified helium. These materials do not pose a hazard for fast spreading fires. The occupancy is classified as a Low Hazard Industrial Occupancy.

Also applicable to the Collider Tunnel is Life Safety Code Chapter 30, Special Structure and High Rise Buildings. Chapter 30 defines the Collider enclosures as windowless underground structures. Since there is a total occupancy of under 50 people, this does not have a major impact.

Furthermore, the Collider Tunnel is only occupied for servicing the beamline equipment. As such the Tunnel is not normally occupied. They are therefore considered a Special Purpose Industrial Occupancy in the context of NFPA 101.

Occupant Load

For Special Purpose Industrial Occupancies, the occupancy load is determined by "the maximum number of persons to occupy the area under any probable condition" (NFPA 101 28-1.7). The maximum period of occupancy will be during beamline construction. Based on the experiences with other BNL accelerators, the maximum occupancy for any one segment of Tunnel sextant between exits will be 6. Therefore, the Magnet Enclosure exits are based on serving three people.

Capacity of Exits

All exit paths have a clear width in excess of 36 inches (NFPA 101-91, 28-2.3). The exit capacity is rated above the 180 persons, while the occupancy is well below 10 for anyone area of the Tunnel.

Number and Arrangement of Means of Egress

Attachment 1 shows the overall layout of the Collider. The Collider is divided into six pie shaped slices, called sextants. Positions around the Collider are also referred to by there relative position on the face of a clock, with north being the 12 o'clock position.

Sextant regions at the 1, 9 and 11 o'clock positions are equipped with five exits each. There are two types of exits. The first type is a standard exit, which has set of standard stairs to the outside. The second type is a ladder exit, in which a the exit path goes through an Exit/Equipment Enclosure Alcove and then up a ladder to grade. The exits alternate between these two types, as you go around the Collider Ring (see Attachment 1 for locations).

The experimental halls at 2, 4, 6 and 8 o'clock provide one other exit at both ends of their structure. A utility tunnel connects the support buildings to the Collider Tunnel and provides an additional exit.

Travel Distance to Exits

Travel distances to theses exits approaches 220 feet. The Code permits 300 ft. for an unsprinklered, low hazard, industrial occupancy. Travel distances are measured for mid points between two exits. The Exit/Equipment Alcoves are not horizontal exits, even though they have substantial fire ratings. They add 30 ft. travel distance to the egress path. The emergency exhaust penetration through the 8 inch concrete wall voids the separations. The standard exits added much more to the travel distance. In addition the path includes electrical and mechanical equipment. To address this significant addition to the travel distance, the standard exit doorways and entrances to the support structures should be upgraded to horizontal exits by installing 1-1/2 hour-rated doors (Recommendation 1).

The three Equipment/Emergency Exit Alcoves are equipped with stair/walkways over the beamlines for ready access to either side. These sections of the Collider Tunnel are of cast concrete and in a form to provide greater head room. Greater than 6 ft. eight inches has been provided for the head clearance over the beamlines.

Discharge from Exits

The central alcove is designed with a walkway to the outside, while the other two are supplied with ladders. Ladders are permitted for industrial occupancies (NFPA 101-91, 28-2.2.10). As part of the RHIC construction project, the ladders will meet ANSI A14.3. Ladder must serve three or less people (see Occupant Load).

The remaining three sextants have similar exit arrangements as described previously plus the following: Sextant 3 has an exit through the spectrometer tunnel, Sextant 5 & 7 have exits to the injection-ejection power supply via a utility/personnel tunnel, plus the injection-ejection tunnel, and Sextant 5 with an additional exit to the Collider Center (Bldg 1005S).

Exits from the Collider Tunnel to the transition structures of the experimental halls will be by stair.

Personnel that reach the entrance door of a standard stair exit, are considered to be in a protected Exit Enclosure. The walls of these enclosures are generic 6 inch concrete block. This has a generic rating of over two hours, as per the American Iinsurance Service Group guidelines[3]. The doors to the enclosures are typically fire rated, 1-1/2 hour for entrances to exit stairways.

Two classes of doors do not have ratings and must be upgraded to meet horizontal exiting requirements. These are: 1) the door from the Collider Tunnel to the Support structures (requires 1-1/2 hour doors); and 2) from the Collider Tunnel to the center sextant stairways (1-1/2 for horizontal exits).

Emergency Lighting and Marking of Means of Egress

Fluorescent lighting is provided throughout the path of egress.

As a windowless structure, the facility is required to have emergency lighting. This will be accomplished by having an emergency generator for standby power. Part of the normal lighting fixture will be powered from an emergency circuit. Lighting level will comply with NFPA 101. Collider Tunnel's lighting and egress path will be on that generator. Since the highest occupancy load will occur during construction, the emergency generator should be in service prior to beam line construction (Recommendation 4).

Emergency exit signs will be provided along the exit path to clearly delineate the route.

Protection of Vertical Openings

There are no vertical opening in this building.

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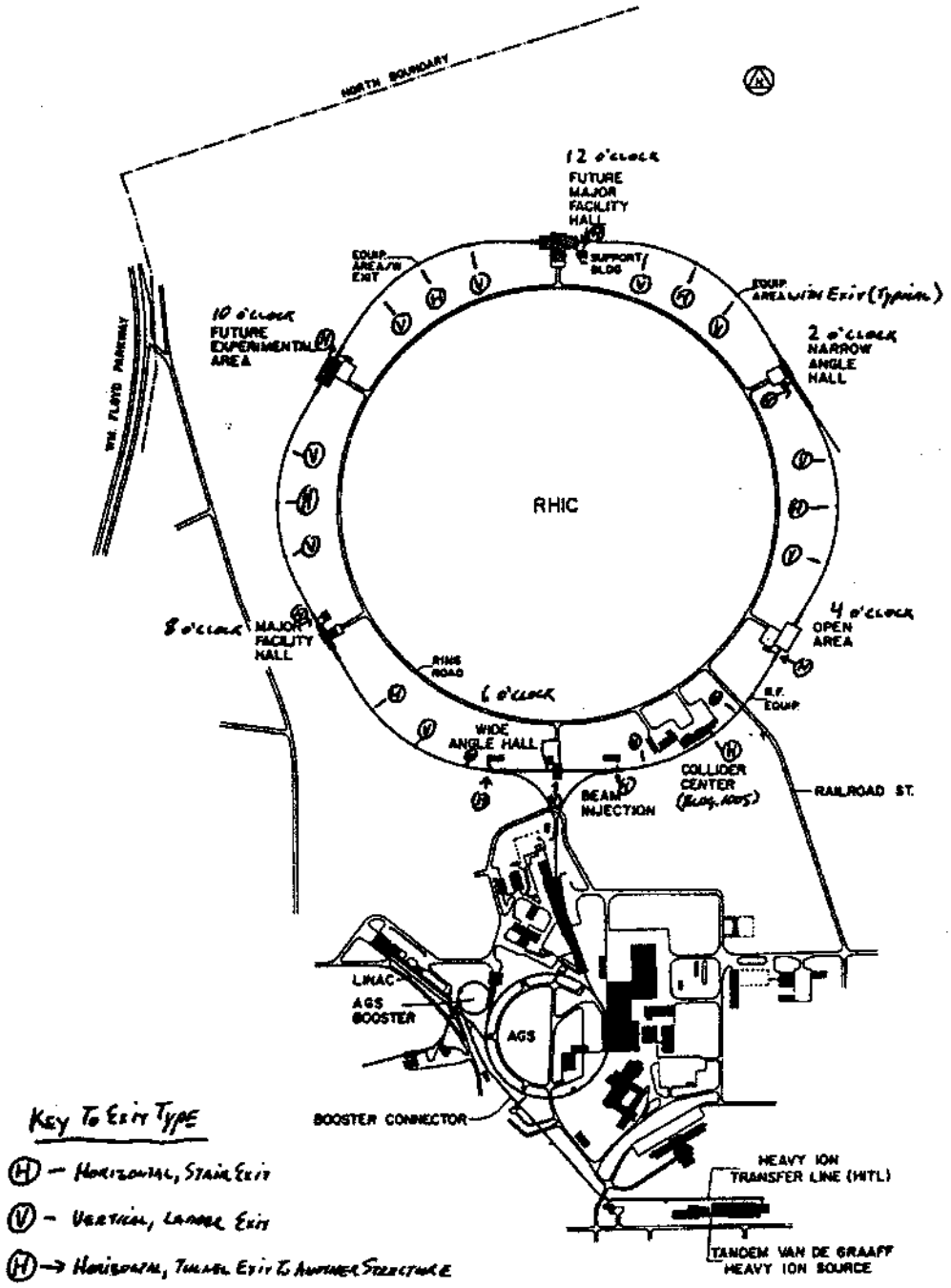
[3]Fire Resistnace Ratings, Engineering and Safety Service, American Insurance Services Group, Inc., FR-1, 1985.

Attachment 1

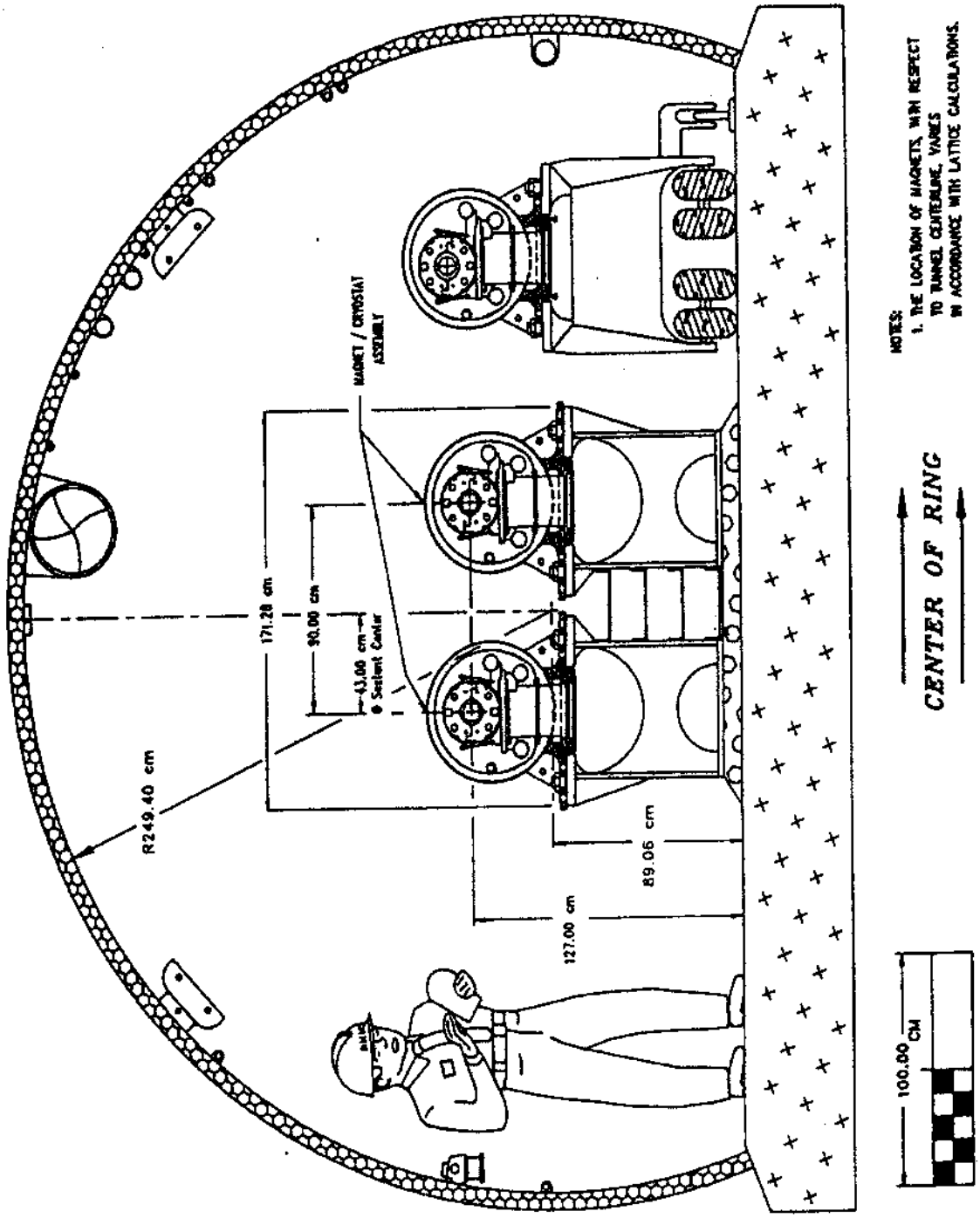
RHIC Area Map



RHIC SITE MAP

Attachment 2

Tunnel Cross Section


MAGNET / CRYOSTAT ASSEMBLY
171.28 cm
90.00 cm
43.00 cm
Sextant Center
R249.40 cm
89.06 cm
127.00 cm
CENTER OF RING
100.00 CM
NOTES:
1. THE LOCATION OF MAGNETS, WITH RESPECT TO TUNNEL CENTERLINE, VARIES IN ACCORDANCE WITH LATTICE CALCULATIONS.

Attachment 3

Cost Estimates for Tunnel Sprinklers

Proc. 024.1 Effective 9/11/87

BROOKHAVEN NATIONAL LABORATORY
PLANT ENGINEERING DIVISION

COST ESTIMATE

SHEET NUMBER 1 OF 1

PROJECT TITLE SPRINKLER SYSTEM INSTALLATION

BUILDING: RHIC

JOB NUMBER: LATER

FAC/CIP/ILR NUMBER: LATER

BY: S.G.

ACCOUNT NUMBER: LATER

DATE: OCT. 18,1990

DESCRIPTION	QUANT.	MATERIAL UNIT	MATERIAL TOTAL	LABOR UNIT	LABOR TOTAL	COST TOTAL
Victaulic mechanical-T bolted branch outlet	550	33.0	18150	55.0	21175	39325
1" wrought male street adapter Nibco 604	550	3.00	1650	55.0	9680	11330
Type "K" 1" copper tubing in 100 ft. coils with clevis hangers 10' o.c.	11000	200	22000	55.0	73205	95205
1" cast copper street elbow Nibco 407-S	550	4.00	2200	55.0	10890	13090
1"x 1/2" copper adapter sweat to threaded female end Steamline Model W-1265	550	4.00	2200	55.0	9680	11880
Viking exsposed pendent "Micromatic" model M, 1/2" NPT, 1/2" orfice natural bronze finish	550	4.00	2200	55.0	15125	17325
Hydrostatic testing of sprinkler branch lines					L.S.	10000
				SUB_	TOTAL	198155
					OH&P	52511
			26½%		TOTAL	250666

NOTES:

1. ESTIMATE ASSUMES EXISTING SPRINKLER MAIN AND STATIONS
2. ESTIMATE FOR INSTALLATION OF BRANCH LINES AND SPRINKLER HEADS ONLY

BROOKHAVEN NATIONAL LABORATORY
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E-MAIL

Office of the Director

September 24, 1996

Dr. Carson L. Nealy
Brookhaven Group Manager
Brookhaven Group
U.S. Department of Energy
Upton, New York 11973

Dear Dr. Nealy:

Subject: Phenix Collider Hall Dead End Exemption - Building 1008

This letter is to request your concurrence on a Life Safety Code Equivalency (LSC) at the RHIC Tunnel segment adjacent to Building 1008.

The Life Safety Code limits the maximum dead end travel distance to 50 feet. An exit path is being eliminated due to radiation concerns during a Design Basis Accident. The resulting dead end distance becomes 110 feet. Warning signs are being installed to reduce the hazard to an equivalent level.

An informal facility review of this proposed configuration was conducted at the beginning of September by J. Yeck, J. Zamorowski, and the RHIC Safety Staff. Due to time constraints, a response by mid-October will avoid accrual of costs to the project.

Sincerely,

M. S. Davis
Associate Director

SD/jl/dw
Attach: Detailed Report
cc: W. R. Casey
R. Diem
J. Levesque
S. Musolino
J. Yeck
FP5120.96

TECHNICAL DETAILS
FOR THE EQUIVALENCY REQUEST
FOR DEAD END DISTANCE
ADJACENT TO THE PHENIX COLLIDER HALL
BUILDING 1008

September, 1996

Prepared by:

J. Levesque
Fire Protection Engineer

Reviewed by:

J. Eckroth
Fire Protection Engineer

Code Citation

The National Fire Protection Association's Life Safety Code, 1994 Edition, Chapter 28-2.5.2 (Dead End) and 28-2.5.3 (Common Path) states: "Dead end corridors within general industrial and special purpose industrial shall not exceed 50 feet," and "Common path of travel in general industrial and special purpose occupancies shall not exceed 50 feet."

Facility Arrangement

See the attached drawing.

The subject analysis addresses the tunnel segment just north of Building 1008. This segment of tunnel is a one story, underground structure with concrete floors, concrete walls, and a concrete ceiling. A portion of the east wall is an insulated metal panel with exterior shielding block. The southern part of the tunnel is sealed off by steel muon plates that completely cover the tunnel opening. An exit door on the east wall was intended to limit the dead end distance/common path of the tunnel to under 50 feet. When this door is sealed off by the shielding blocks, the dead end distance/common path of travel will become 110 feet.

This area is normally not occupied. During construction and maintenance, a maximum anticipated occupancy during these infrequent periods is not expected to exceed five (5) people.

Refer to the RHIC SAD for justification as a special purpose, industrial occupancy under National Fire Protection Association's Life Safety Code (LSC, NFPA 101). Cryogenic Magnets used for RHIC beam transport will occupy this segment of the tunnel. The magnets are of metal construction and cooled with cryogenic helium. Minor amounts of combustibles in the form of insulation material are located within the core of the magnet. The cable trays are metal and the cables are Underwriters Laboratories, Inc. (U.L.) listed as TC, CM and high voltage assemblies. A U.L. listing requires the cables to pass the IEEE383 Flame Spread Test. There are no other permanent combustibles present in this region.

Fire detection for the tunnel structure is provided by smoke detectors, 40 feet on center. Ionization detectors alternate with photoelectric detectors. Fixed temperature/rate of rise heat detectors are provided on a separate circuit from the smoke detection. Both detection circuits are connected to the fire alarm panel in Building 1008A. Alarm bells and strobes are provided throughout the tunnel. The Brookhaven National Laboratory Fire/Rescue Group response time to the facility is within five minutes of an alarm.

A fan forced smoke removal system is provided to exchange the smoke buildup in the tunnel. The system is normally activated manually. However, the system is automatically activated by the fire alarm system in the area when the tunnel is in the "Occupied Mode of Operation." This system is beyond the Life Safety Code requirements.

The entire tunnel has emergency lighting via normal light fixtures which are powered by an emergency generator system. The smoke removal system is also on emergency backup power. The emergency power system meets the requirements of NFPA 110 for a Level II service.

Reason for Deviation

The subject exit door requires the construction of a labyrinth through the shielding block to the Phenix Counting House. Insufficient horizontal distance exists to configure the labyrinth effectively. In a Design Base Accident (DBA) for the loss of beam, the best configuration of the labyrinth cannot reliably predict the radiation levels in the Counting House. This issue has been reviewed by RHIC's Radiation Safety Committee and deemed a risk worth mitigating (Reference BNL's Radiation Safety Committee Meeting Minutes of September, 1996). Potential exposure levels can exceed 250 mrem in the Counting House.

Reconfiguration of the labyrinth would be difficult, costly, and impact the quality of Physics. To properly configure the labyrinth, the length needs to be increased toward the Phenix Counting House. Utilities, services, and foundation have already been adjusted to accommodate the location of the Counting House. The cost of a change would be approximately $50,000. Moving back the Phenix Counting House to accommodate a larger labyrinth would increase the length of cables between the detector and the Counting House, attenuate the signal, and be detrimental to the experimental program.

Summary of Hazard

1. A person in the region of the tunnel will travel approximately 75 feet down the dead end before realizing there is no exit. Approximately 150 feet of extra travel will be incurred.

2. An excessive common path of travel is present.

Mitigating the Hazard

1. Posting of "No Exit" signs will warn occupants, who should be relatively familiar with the area, not to travel down the dead end space to seek an exit.

2. Smoke detection will notify occupants in the early stages of the fire development of the need to start evacuation.

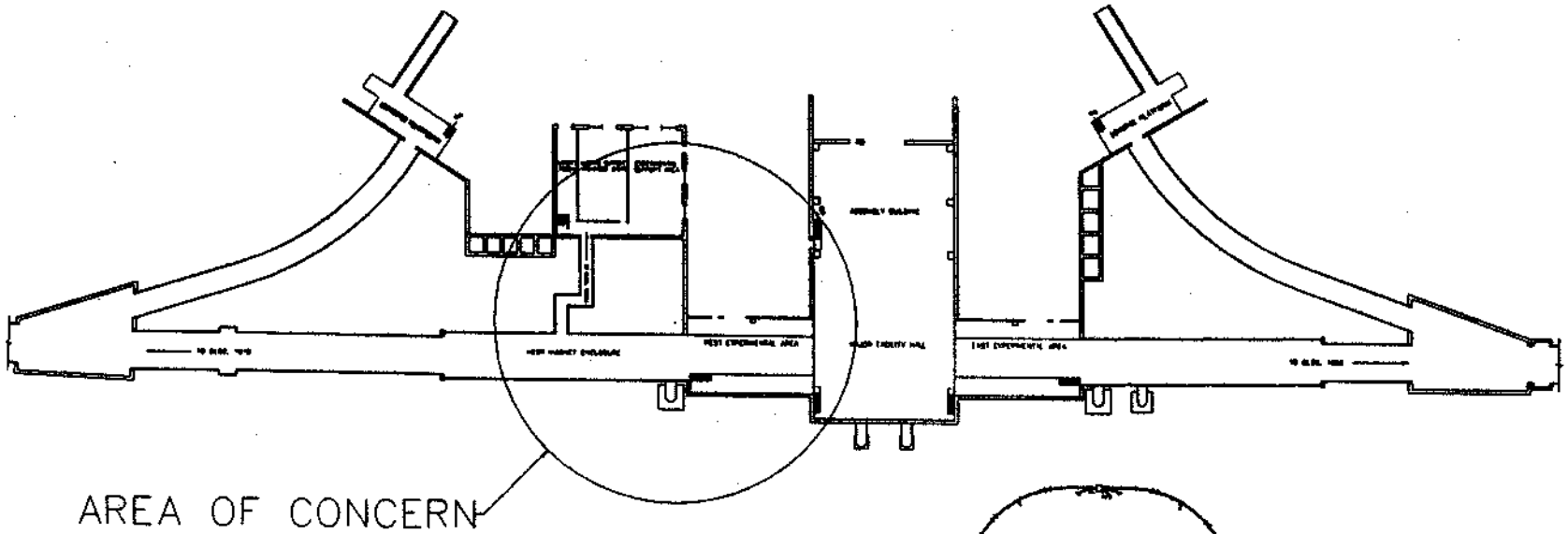
3. The smoke removal system, and the inherent low combustibility will limit the fire from endangering an exiting individual.

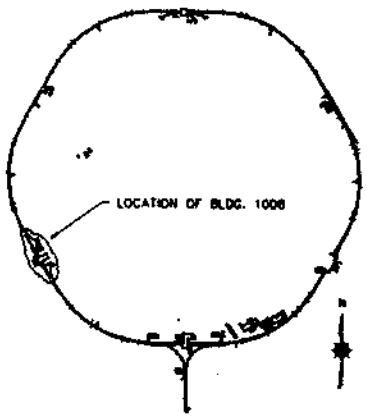
4. The smoke removal system will minimize the impact of impaired visibility normally encountered by smokey fires.

Conclusion

The occupants will be familiar with the exit configuration in the tunnel. The posting of "No Exit" signs will serve as a reminder and will negate the concern of excessive travel to an exit. The safety system for early detection and smoke removal allows an increase of a common path of travel without detracting from the level of safety.

R.H.I.C. MAJOR FACILITY HALL
BLDG. 1008



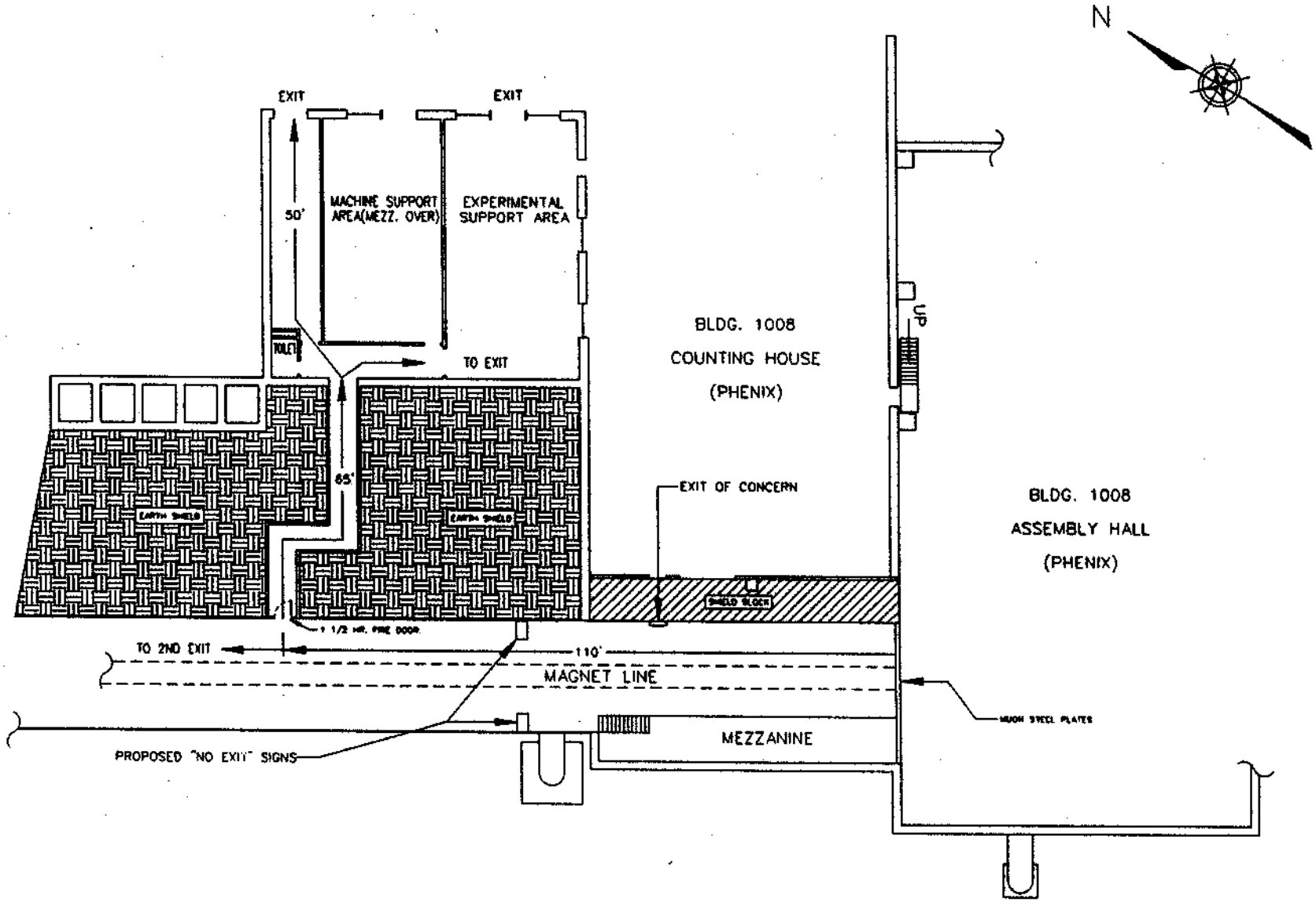


KEY PLAN
NOT TO SCALE

DWG. TITLE	REVISION #1	DATE 12/21/94
bnl aui	BROOKHAVEN NATIONAL LABORATORY AUI UPTON, NEW YORK 11973 UNDER CONTRACT WITH THE UNITED STATES DEPARTMENT OF ENERGY	
PLANT ENGINEERING BLDG. 134C (MAC) 35 BROOKHAVEN AVE.	DWG. TITLE 1008	DATE 5/12/92
	SCALE N.T.S.	SHEET 1 OF 1

PHENIX COLLIDER HALL

DEAD END EXEMPTION DETAILS



NOV 0 6 1996

Department of Energy
Brookhaven Area Office
Building 464
P.O. Box 5000
Upton, New York 11973

October 31, 1996

W.R. Casey
S. Ozaki

Dr. M.S. Davis
Associated Universities, Inc.
Brookhaven National Laboratory
Upton, New York 11973

Dear Dr. Davis:

SUBJECT: PHENIX COLLIDER HALL DEAD END EQUIVALENCY

Reference: Memo dated 10/24/96, Langenfeld to Nealy

Enclosed is the referenced memo which approves the equivalency request for the RHIC tunnel dead end adjacent to the Phenix Collider Hall. The mitigating factors as detailed in your request shall be implemented as well as increased emergency lighting and additional signs in the dead end area. Mr. Joseph Levesque of your staff is aware of these requirements.

If you have any further questions, please contact Richard Diem of my staff at extension 2405.

Sincerely,

Carson L. Nealy
Brookhaven Group Manager

Enclosure:
As stated

Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

October 24, 1996

Carson L. Nealy
Brookhaven Group Manager

SUBJECT: PHENIX COLLIDER HALL DEAD END EQUIVALENCY

The Chicago Operations Office is granting this equivalency from Sections 28-2.5.2 and 28-2.5.3 of the 1994 Edition of the National Fire Protection Association Life Safety Code (NFPA 101). Exceeding the dead end and common path of travel distance of NFPA 101 is acceptable because of the following mitigating factors; limited number of employees with access to the area, their familiarity with the area, additional signs, increased emergency lighting, limited combustible materials in the area, smoke detection for early warning, and a smoke removal system. These factors will allow the employees to exit safely during an emergency.

If you have any questions, please feel free to contact Michael O. Saar at 630-252-2245.

Cherri J. Langenfeld
Manager

To: Musolino
From: Joe Levesque <Levesque@mail.sep.bnl.gov>
Subject: PHENIX Equilavancy Request
Cc: stevens@bnldag.ags.bnl.gov, kane, durnan,etkin,marotta, eckroth
Bcc:
X-Attachments:

Steve,

Here is a status report on the "Equivalency" request for Bldg. 1008's dead end distance.

Dick Diem has it in his hands. We walked the area. He is asking for two items (it is in the nature for people to add their two cents, but in Kick's case it is about $800).

1) The dead end tunnel section should be illuminated by battery pack emergency lights (as a backup to the emergency generator set, to improve reliability of the lighting).

2) The "No Exit" Signs should be Tritium type (i.e., self illuminating).

(Steve M.: Someone within RHIC needs to cut a PO for this or an ILR to PE).

He is supporting the activity. He believes that Chicago Ops Office must review it technically, then it will be approved (Wahsington does not have to be involved since it is an Equivalency and not an exemption).

FP5020.96 (Bldg. 1008)

10/1/96